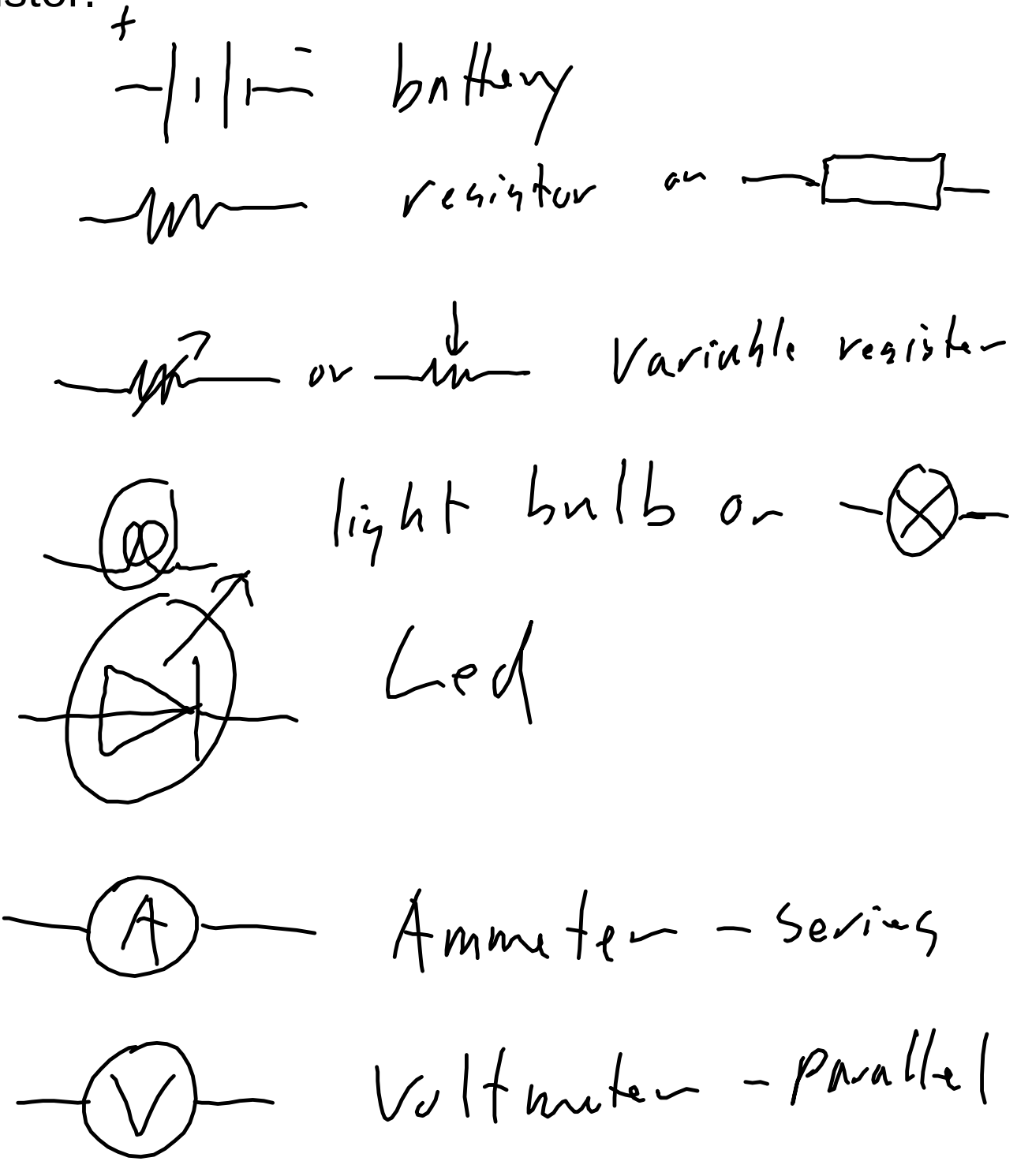
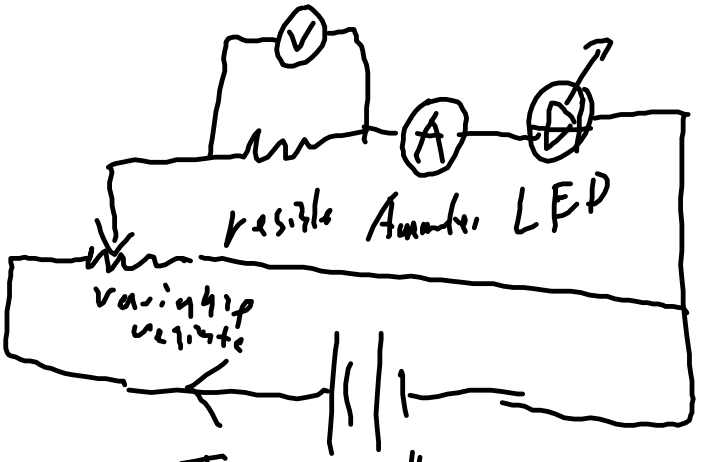
Ohm's "Law" and Power

Look at a circuit with a 6.0 V battery connected to a 330 ohm resistor and a LED light with an ammeter and a voltmeter connected across the resistor.





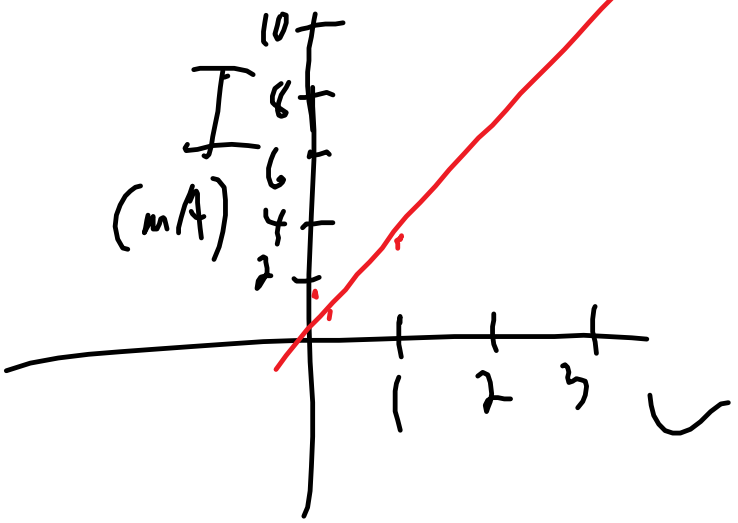
I

current

- opposite e^- flow

V (V)	I (mA)
0 0	0.0
0.5	1.6
0.6	2.1
1.0	3.3
2.1	6.6
3.0	9.5
3 5	10.8

Ohmic Resistor



I vs V

constant slope

$\text{Slope} = \frac{I}{V} = \frac{1}{R}$

define resistance as the ratio of $\frac{V}{I} = R$

units ohms, $\Omega = \frac{V}{A}$

Resistors are circuit elements that dissipate electrical energy as heat.

Resistance is the ratio of V/I influences the current for particular applied voltages.

Most resistors are constructed to have a constant resistance over a range of voltages. Ohmic.

Diodes alter their resistance depending on the voltage - not ohmic.

The rate of energy transferred into heat by a resistor or light by a LED is the power output of that circuit element.

P=energy/time V=energy/charge I=charge/time

P=VI for a circuit element
Using ohm's law

$P=V^2/r = I^2R = VI$

For the above circuit, when the voltage across

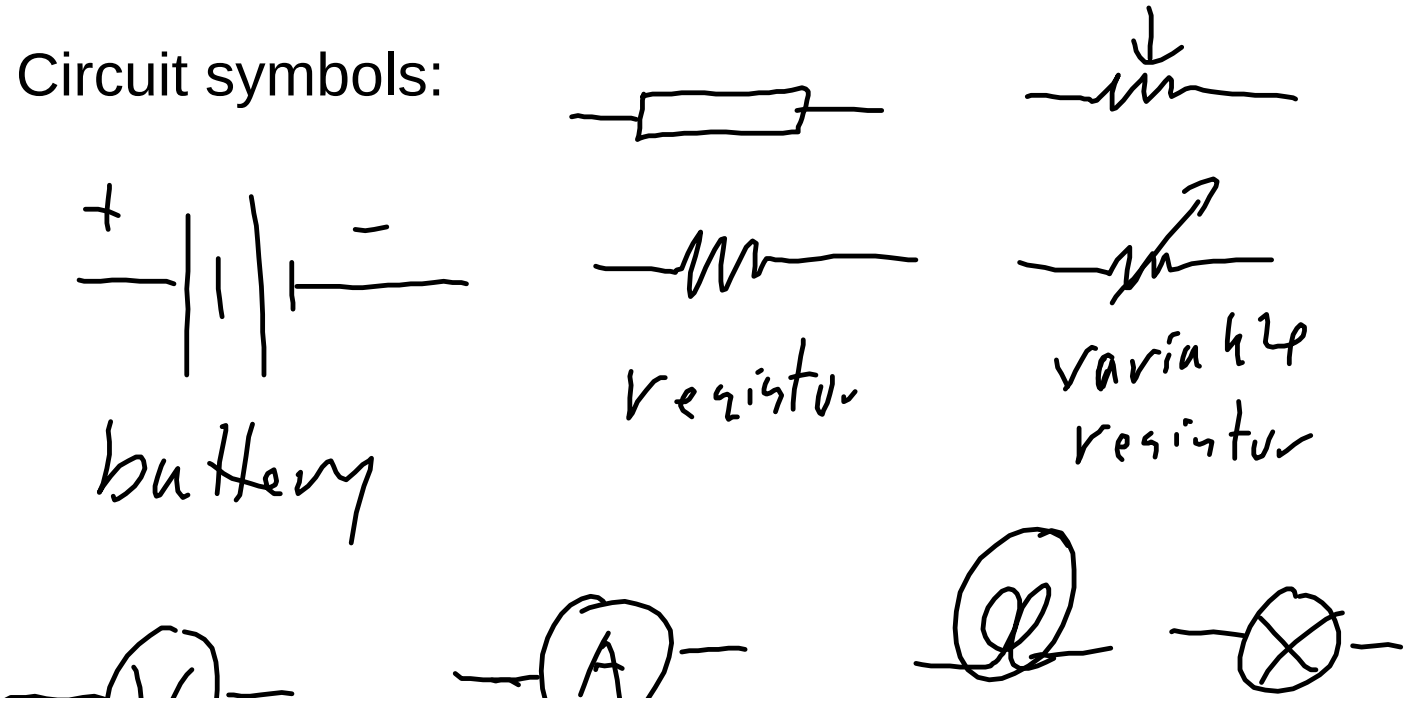
the resistor is 3.0V the current is 9.5mA. Determine

a) The resistance of the resistor from that data and compare to the listed value of 330 ohms.
b) The power output of the resistor.
c) How many electrons pass through the resistor per unit time?
d) If the voltage across the LED is 1.9V what is its resistance? (current is 9.5mA for both because they are in series)

Ohm's Law and Power

Set up a circuit with a 6.0 V battery connected to a variable resistor, a 330 ohm resistor and a light emitting diode (LED) with voltmeters across the resistor and diode and an ammeter for the current through the resistor and diode.

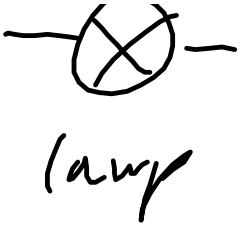
Circuit symbols:



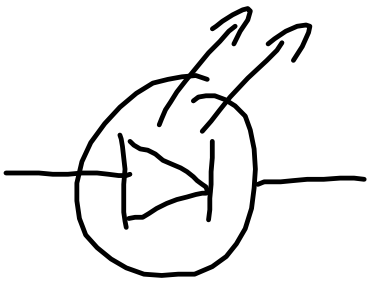
Voltmeter
- parallel

Ammeter
- series

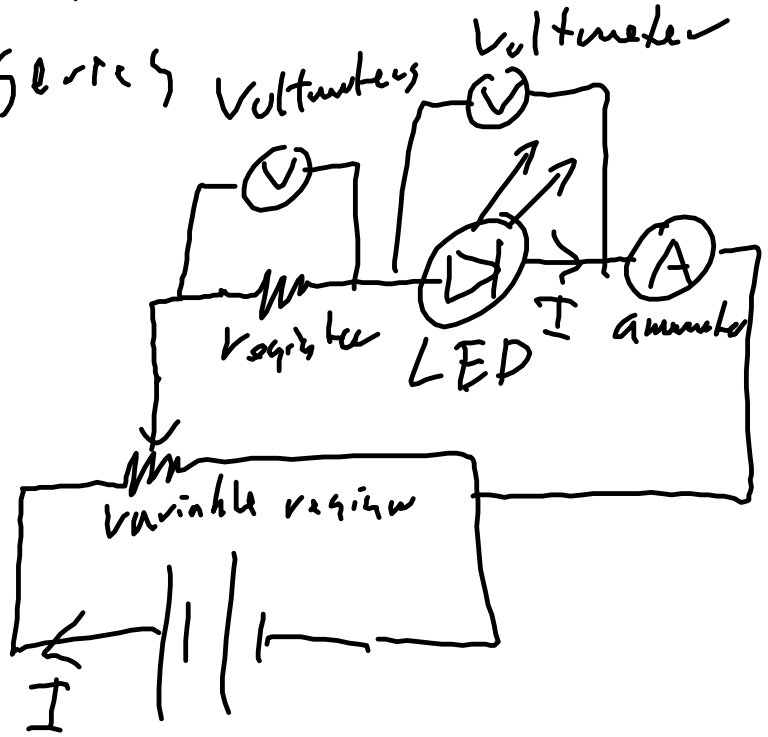
lamp



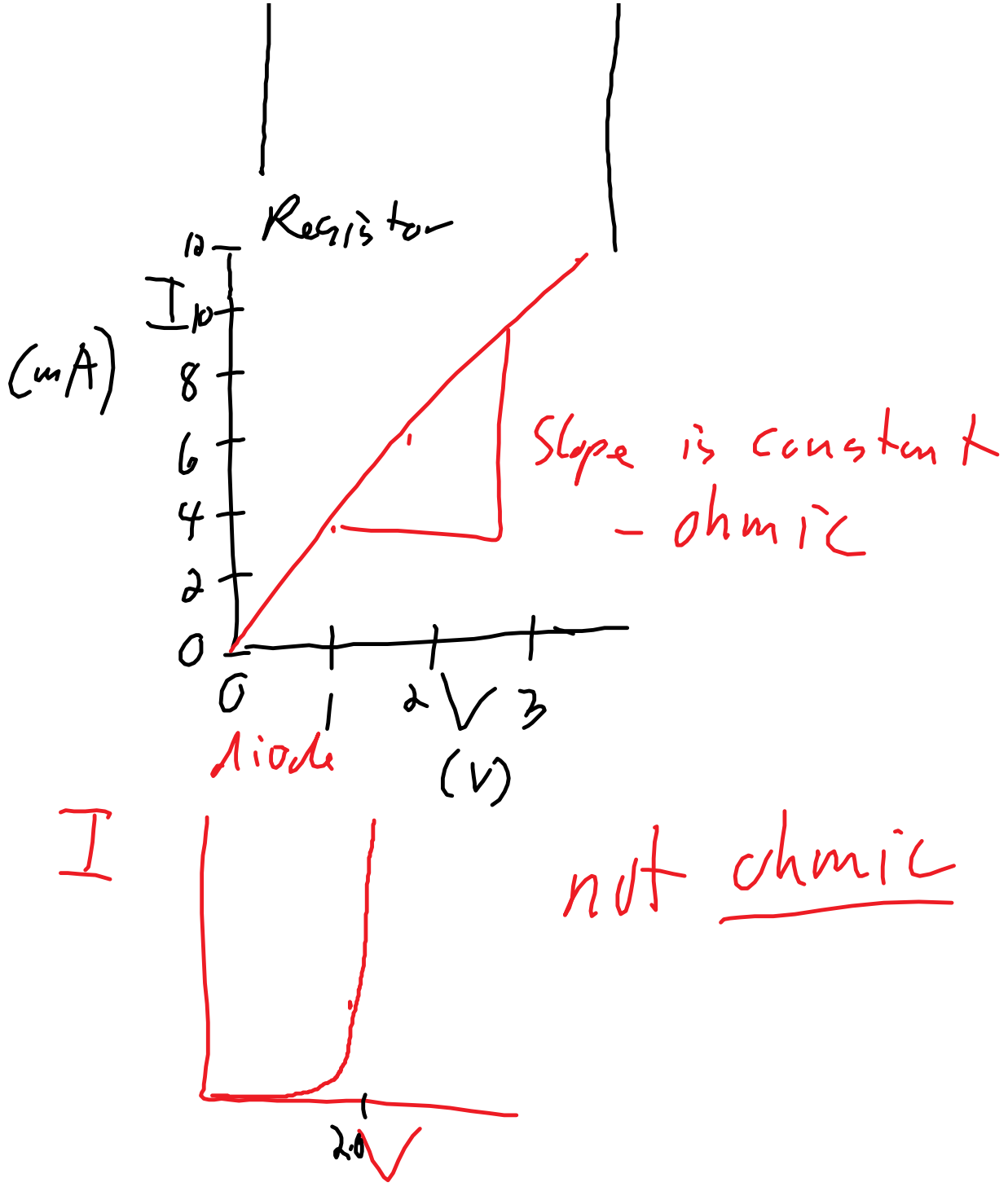
lamp



LED



V_1 V of Resistor (V)	V_2 V of diode (V)	I Current (mA)
1.1	1.8	3.5
1.9	1.8	5.6
2.9	1.9	8.9
3.7	1.9	11.0
0.5	1.8	1.6



Resistor - a circuit element that dissipates electrical energy as heat.
Usually constructed to be ohmic - the resistance is constant over a variety of voltages and currents.

Resistance, R is the ratio of Voltage and current.
R=V/I

Something with high resistance will have low current for a set voltage.

Units: ohm, $\Omega = V/A$

LED is not ohmic - the resistance changes with different voltages and currents.

Power, P is rate of doing work or the rate of change in energy.

P=energy/time V=energy/charge I=charge/time

$P=W/t = VI = V^2/R = I^2R$

Eg. In our circuit, when the voltage across the resistor is 3.7V the current was 11.0 mA and the voltage of the diode was 1.9V

a) What is the resistance of the two devices at that current?
b) What is the power output of the devices?
c) When the voltage of the resistor is 1.1V, the current was 3.5mA and diode voltage was 1.8V. What is the resistance and power output of each?

a) $R = V/I = 3.7V / 11.0mA = 0.33\ k\Omega = 330\Omega$ For

the resistor
For the diode R=1.9V/11.0mA = 173Ω

b) P=VI = 3.7V x 11.0 mA = 3.7x11=40.7 =41 mW
P= 1.9x11=20.9 = 21mW

c) R =V/I = 1.1V/ 3.5mA = 1.1/3.5=0.3143 = 310Ω For the resistor
For the diode R=1.8V/3.5mA = 1.8/3.5=0.5143 = 510Ω

P=VI = 1.1V x 3.5 mA = 1.1x3.5=3.85 =3.8 mW
P= 1.8x3.5=6.3 6.3mW for the diode

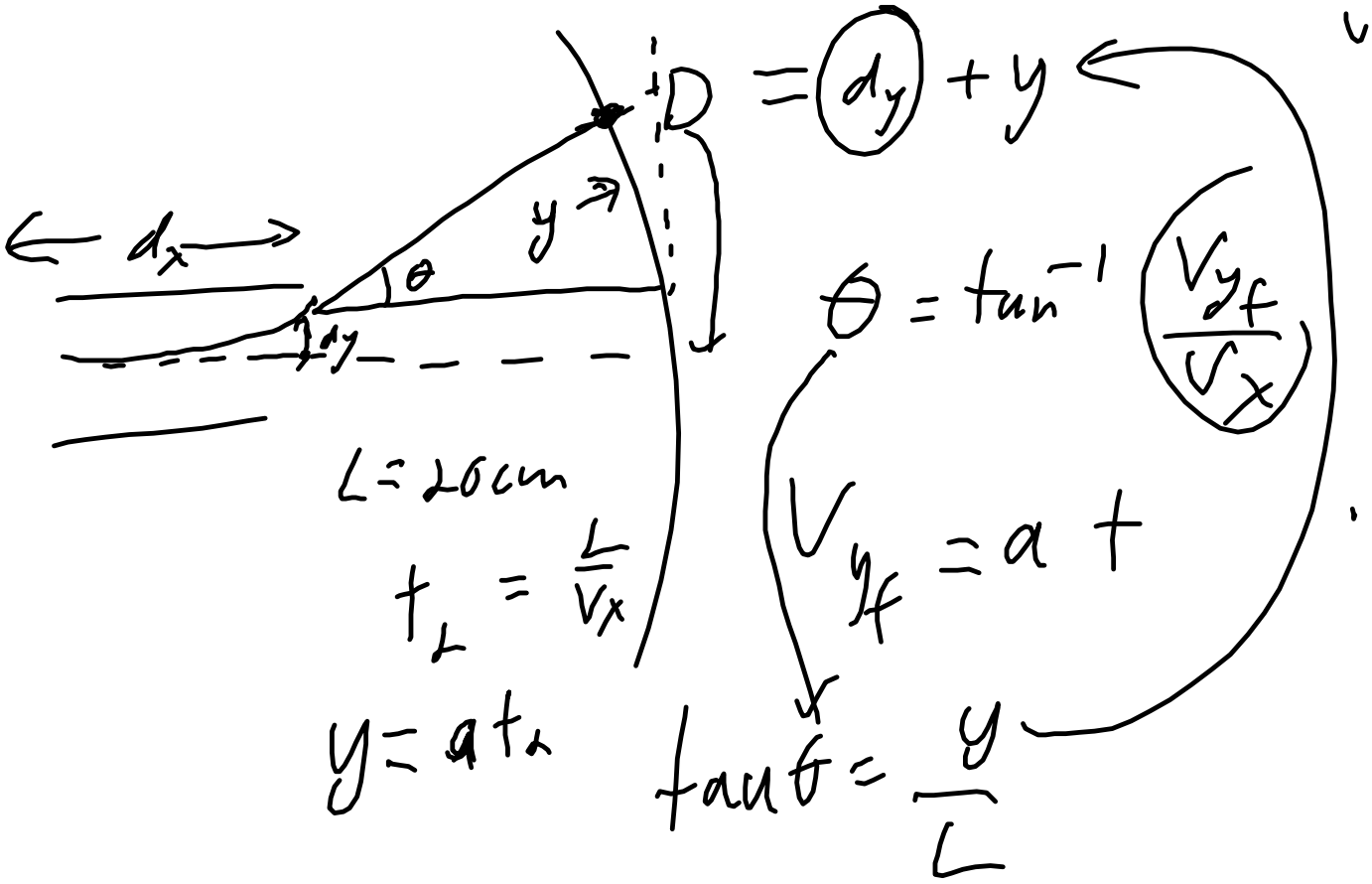
J lab

$$D = \frac{1}{2}\frac{e(d/2 + L)\,V}{d\,V_q}$$

$$D = \frac{1}{2}\frac{(0.06)(0.06/2 + 0.2)\,150\,V}{0.02\,(500\,V)}$$

$$= 0.1075\,m = \boxed{0.10\,m}$$

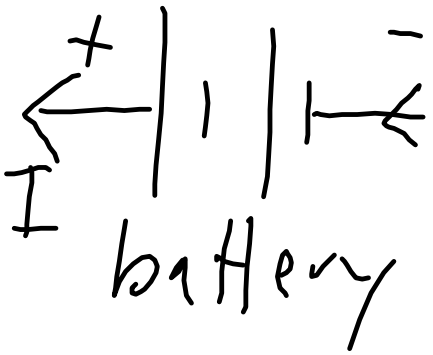
$$10.4\,cm$$



Ohm's "Law" and Power

We have a circuit setup with a battery connected to a variable resistor (also called potentiometer or rheostat) then we have a 330 ohm resistor in series with a light emitting diode (LED). We will measure the current through the resistor and LED with an ammeter and we will measure the voltage across the resistor and LED with 2 voltmeters. Let us

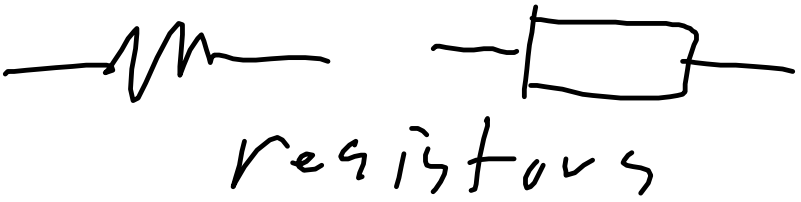
observe:



battery

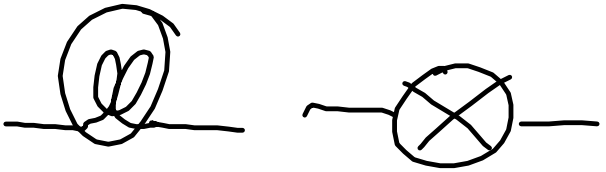
I is conventional current in ampères, A.

- electron flow is opposite I.

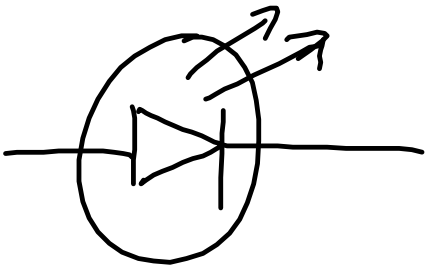


resistors

variable resistors



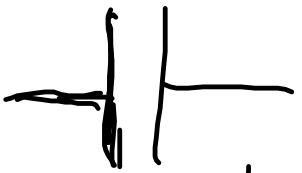
light bulb



LED

Ammeter

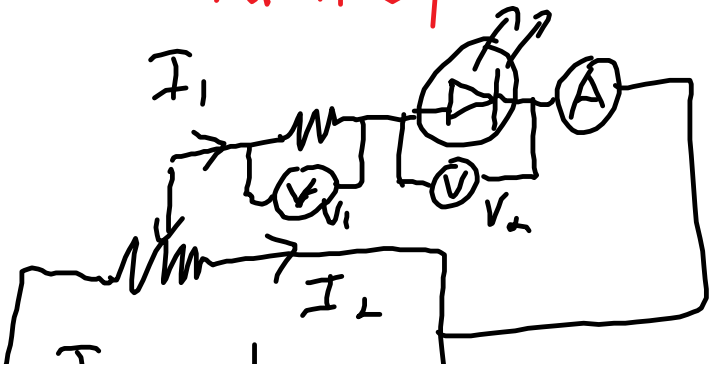
Voltmeter



Capacitor

* Series

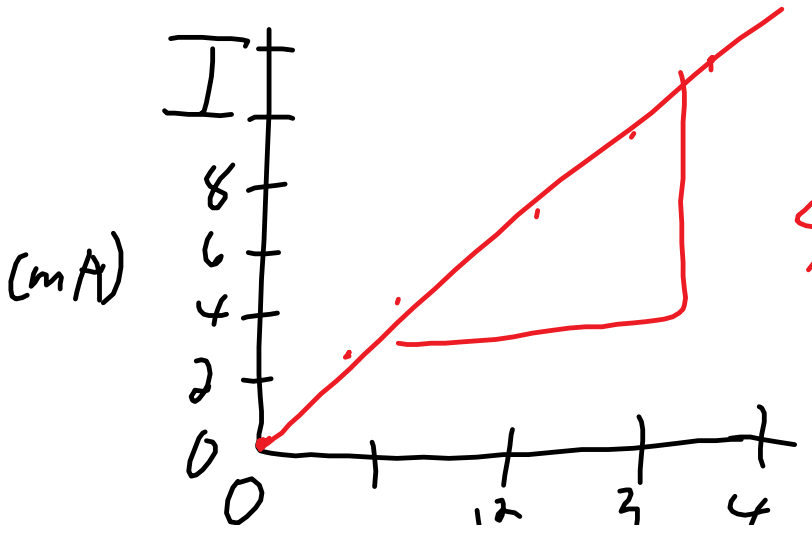
* Parallel



$V = 6.0\,V$

Voltage across resistor V_1 (V)	Voltage across diode V_2 (V)	Current through R + Diode I_1 (mA)
0.0	0.0	0.0
0.0	0.5	0.0
0.7	2.0	2.2
1.2	2.0	3.9
2.1	2.1	6.6
3.0	2.1	9.2
3.8	2.1	11.4

resistor



linear

Slope is constant

$$\frac{I}{V} = \frac{1}{R}$$

Resistance, R is ratio of Voltage across a circuit element to the current through the element.
R=V/I

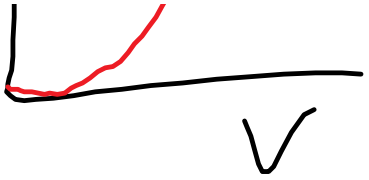
Ohm's Law V=IR is just a definition of resistance.

Units: Ohms, Ω

1 Ω=V/A

Resistor - a circuit element that dissipates electrical energy as heat. Made to have a constant resistance over a range of V and I. "Ohmic" resistance is constant.

Diode - circuit element made of semiconductors that has many functions - LEDs give off light with limited heat given off.



Resistance is not constant.

Power, P
Is the rate of doing work or change energy.

P=energy/time V=energy/charge I=charge/time

VI= energy/q x q/t = energy/time

$P=VI = V^2/R = I^2R$ from V=IR

From our data
Voltage across the resistor is 3.0V when the current is 9.2 mA and the voltage across the diode is 2.1V. Determine

a) The resistance of each circuit element
b) The power output of each device
c) Repeat for V_1 = 1.2V I_1 = 3.9mA V_2=2.0V

a) R=V/I 3.0V/9.2mA=0.3261kΩ= resistor: 330Ω
   R= 2.1/9.2=0.2283 diode: 230Ω
b) P=VI 3x9.2=27.6 28mW resistor
   2.1x9.2=19.32 19mW
c) 1.2/3.9=0.3077 resistor 310Ω
   R= 1.2/9.2=0.1304 diode: 130Ω
d) P=VI 1.2x3.9=4.68 4.7mW resistor
   2.0x3.9=7.8 7.8mW diode